Bulletin 448

Starting VEGETABLE *Plants*

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CORNELL EXTENSION BULLETIN

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Starting Vegetable Plants

G. J. RALEIGH

INFORMATION from many sources indicates that the value of vegetable crops grown from plants started in a seedbed is almost one-half of the total value of all vegetables, except potatoes, produced in New York State. Many of these plants are grown in coldframes, hotbeds, and plant houses. The most important vegetable plants grown in such structures are tomatoes, cabbage, lettuce, melons, celery, cauliflower, peppers, eggplant, and Brussels sprouts. Cost of production on an acreage basis for each of these vegetables is high. As a result, failures mean a great loss. The use of poorly grown plants of local or of distant origin often results in reduced yields.

In most of the State, vegetable growers are able to buy locally grown plants at relatively reasonable prices. Before building any type of plant-growing structure, a grower should consider whether he wishes to master the technique of plant growing or prefers to buy plants from some one who grows them well.

Plants of similar quality usually can be grown cheaper than they can be purchased. Moreover, the grower who produces his own plants is much less likely to be troubled by such diseases as club root and yellows of cabbage which are commonly introduced by purchasing plants from infested soils. Southern-grown and inferior locally grown plants may sell at low prices, but too often results with such plants are disappointing.

When early maturity is of importance, as in most market-garden sections of the State, the kind of plants used often determines whether or not the crop will be profitable. Large, sturdy plants with good root systems commence growth quickly after careful transplanting and produce crops earlier than do poorly grown plants. The better plants are more costly to grow because they require more room in the plant-growing structure and more labor for their production than do plants that are spindling as a result of crowding. Whether it will pay to produce the better type of plant may depend on market demands and on the kind of soil available for growing the crop. It might not be profitable to grow tomato plants in pots if the only soil available for an early market crop were of a heavy clay type. Growers on relatively sandy soils, even though they used inferior plants, could mature tomatoes eariler than could the careful plant grower who was forced to grow the crop on heavy soils.

Plant-growing Structures

SEVERAL types of plant-growing structures are used in the State. A grower who has not yet invested in plant-growing equipment should give considerable thought to the type best fitted to his needs. It is important that the structures be large enough to grow the number and kinds of plants required. Climate, acreage of various vegetables to be grown, and market demand for plants should be considered. The county agricultural agent is glad to give suggestions relative to structures that may best meet individual needs.

Location

Convenience demands that the structure be near the house. Coldframes and hotbeds should be built on well-drained southern slopes protected from the north and west winds. If possible, a supply of running water should be available. Single-width coldframes and hotbeds should run approximately east and west, so that the sash will slope to the south or slightly east of south.

Coldframes

A coldframe is the simplest plant-growing structure. It is a board frame covered with sash, glass-cloth, or cloth, as protection against the cold, but is not provided with artificial heat. Standard sash are 3 by 6 feet. For that reason, the coldframe should be 5 feet 11 inches wide and any multiple of 3 feet in length. To construct a 2-sash coldframe as shown in figure 1, the following materials are needed:

1 piece 2″ x 2″ x 6′
1 piece 2″ x 8″ x 6′
3 pieces 2″ x 14″ x 6′
2 pieces 1″ x 3″ x 6′

If the material has to be bought, cypress or chestnut is preferable to other kinds of wood because of their resistance to decay.

Hotbeds

A hotbed has artificial heat in addition to coldframe insulation against the low temperatures of early spring. The heat may be provided by horse manure, hot-air flues, steam, hot water, or electricity. On extremely cold nights, extra protection should be

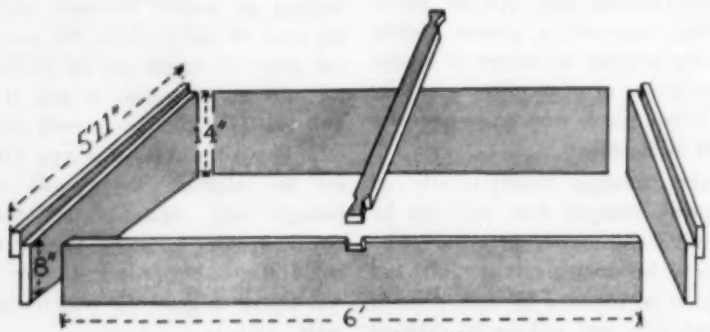

Figure 1. A two-sash coldframe

given plants in hotbeds or coldframes by covering the sash with mats, old blankets, burlap bags sewed together, or with loose straw or hay.

Manure-heated beds

For information on manure-heated beds, one should write to the Department of Vegetable Crops, Cornell University, Ithaca, New York.

Hot-water- and steam-heated beds

Hot water or steam may be economical for the small bed if it can be operated from the home heating plant. For relatively large installations, hot water is probably the most satisfactory way to heat hotbeds.

Electrically heated beds

Like hot water and flue-heated beds, electrically heated hotbeds are permanent installations that require rebuilding only when the outside frame decays. They are always ready to use, are clean and agreeable to work with, and can be converted into coldframes by turning off the electricity. Temperatures can be regulated by the use of a thermostat. It is, of course, necessary to supplement this method of temperature control by ventilating the beds on warm days, otherwise temperatures may become too high even though the thermostat has cut off the current. In general, the electrically heated hotbeds require less labor and attention than do hotbeds heated in other ways but they are somewhat more expensive to operate. The amount of electrical energy required varies widely with the location of the bed, its construction, and the season of the year that it is operated. Hotbeds started about March 15 may be expected to use from 25 to 40 kilowatt hours per square yard for the remainder of the season.

Small beds may be heated with infrared lamps or electric light bulbs.

Construction details of an electrically heated hotbed, as well as of other plant-growing structures, are given in Cornell Extension Bulletin 468, *Structures for Starting and Growing Ornamental Plants.*

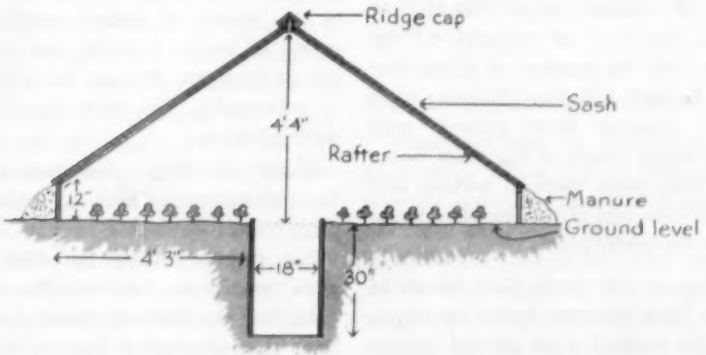

Figure 2. Diagram of a simple sash house

Plant houses

A plant house is better than a hotbed for large-scale plant-growing because temperature and humidity are easier to control and work in the plant house can be done conveniently and comfortably.

One of the simplest is the sash-house which is similar to two coldframes built back to back and with an 18-inch path excavated in the middle so that the operator can get in to care for the plants (figure 2). This type of house is not satisfactory in poorly drained locations. More complete information is given in Leaflet 124, *Sash Greenhouses,* from the United States Department of Agriculture, Washington, D. C.

The small greenhouse may be best for those who grow a large number of plants, as it allows more head room than does the sash house, is easier to ventilate, and shades the plants less than do other structures. A house 18 by 40 feet is a convenient size for the market gardener with from 10 to 20 acres of intensive crops. The kind of crops, the time of maturity of the crops, and the number of plants that may be sold influence the amount of space required. Most growers start early hardy plants in the plant house and then move them to hotbeds and coldframes, and utilize the plant-house space for tender plants.

Some of the small plant houses in New York State are heated by stoves, but this method is not advised because of the variations in temperature in different parts of the house. A hot-water heating system is one of the most satisfactory types.

Even a small plant house should have a room at one end to house the furnace and for benches that may be used when potting plants and the like. Building plans may be obtained from the manufacturers of greenhouse equipment. A list of such manufacturers may be obtained from the Department of Vegetable Crops at Cornell University, Ithaca, New York.

Glass substitutes

In some sections where a considerable amount of coldframe space is required for a short period, the frames are covered with unbleached muslin. Although the initial cost of such covering is less than for glass sash, muslin is not entirely satisfactory because it greatly reduces the amount of light that reaches the plants. Cloth used for covering coldframes should be painted or sprayed with a preservative to increase its length of service. A good mixture for this purpose consists of 2½ pounds of melted paraffin, ½ pound of melted beeswax, and 1 gallon of benzine. Because the solution is inflammable, the work should be done outdoors.

Numerous other glass substitutes for making sashes and for building plant houses are on the market. Their initial cost is usually less than for glass sash. Some transmit ultra-violet light, but experimental evidence indicates that ultra-violet light is of no recognized benefit to the plants.

Sashes made with glass substitutes are likely to blow off the frames unless fastened in some way.

Plant-growing

Soils

Preparation

A SANDY-LOAM soil containing a good supply of organic matter is satisfactory for plant-growing. Soils for plant-growing are often composted a year before they are used by making piles of alternate layers of manure and of soil. The piles should be turned twice during the season. The labor cost of the compost piles may not be justified if good soil that has been in sod the year previous is available.

A soil shredder greatly reduces the amount of labor required to condition the soil as it is brought to the greenhouse.

Sand and peat moss may be mixed with the soil before use.

Unless the soil is known to be fertile, it is well to add a small amount of complete fertilizer as the soil is being prepared. One-fourth pound of 6-12-6 or of a similar fertilizer should be enough for 1 bushel of soil. This is equivalent to about 5 pounds of fertilizer to a cubic yard of soil. The use of larger quantities of fertilizer is likely to cause soft growth or to injure the plants. A test of the conductivity of the solution from a soil gives fairly reliable information about its content of nutrients. If the soil contains considerable manure, it is advisable to use phosphate and potash rather than a complete fertilizer. Too much available nitrogen in the soil tends to produce soft growth.

If the soil becomes deficient in nitrogen, growth is checked and the foliage becomes light green. Applying a granular form of nitrate of soda at the rate of approximately 1/3 pound to 100 square feet of plant bed or area occupied by flats and watering immediately thereafter, in order to wash off any nitrate that may have lodged on the plants and to dissolve the material and carry it into the soil, should stimulate renewed growth of the checked plants. Many growers prefer to apply soluble starter-solution fertilizers, such as 15-30-14, 13-26-13, 20-20-20, and the like, at the dilute doses recommended on the package. Care should be taken not to apply any soluble fertilizer unless it is washed from the foliage immediately after application or it will injure the plants. Some growers prefer to apply nitrogen by watering the plants with a solution made by dissolving nitrate of soda in water at the rate of 1 ounce to 1 gallon of water.

Soil reaction and soluble salts

Vegetables vary in their lime requirements. Those that are more acid-sensitive grow best in soils varying in pH from 6.0 to 6.7. Because the less acid-sensitive vegetables also thrive within this range, it is a desirable range for various kinds of plants, even though the less acid-sensitive plants thrive in soils as acid as pH 5.0. Many

soils used for plant growing are too alkaline or sweet because lime was used in excess quantities without testing the soil to determine whether an application of lime was necessary.

The continued use of water containing large quantities of minerals and heavy manuring of the soil may make the soil alkaline and cause the accumulation of large quantities of soluble salts. Excessive use of urea nitrogen injures plants but cannot be detected by the soluble salts test. In soils that are very well drained, much of the soluble-salt content may be leached from the soil; but to do this, large quantities of water are required. Growers who feel that they are encountering trouble of this kind should consult their county agricultural agent for suggestions. He is glad to test soil for acidity and to suggest whether a conductivity test for soluble salts is advisable.

2,4-D, wood preservative, and other injuries

Severe losses are sometimes caused by careless applications or storage of 2,4-D and similar compounds and by the use of wood preservatives. If in doubt about any material one should consult his county agricultural agent.

Disease and insect control

Soil sterilization

Outbreaks of many of the most serious plant disease and insect troubles can be traced to carelessness in the seedbed. For example, club root of cabbage is often spread from the seedbed. With practically all diseases, it is much easier to prevent them than to cure them. Several kinds of vegetable seeds should be dusted with thiram or captan to reduce the amount of damping-off. Insects that may be easily controlled in the seedbed are sometimes allowed to remain on the plants and are carried to the field where they may cause great damage. More details are given in Cornell Extension Bulletin 206, *Control of Diseases and Insects Affecting Vegetable Crops.*

Soil sterilization is often a valuable aid in disease control. This is discussed in Cornell University Agricultural Experiment Station Bulletin 850, *Soil Fumigation for Nematode and Disease Control.*

Seedage

No plant is better than the seed from which it was produced. Strains and varieties of vegetables vary widely. Some of the large losses incurred in this State by vegetable growers are the result of an inadequate knowledge of the type, yield, and time of maturity of varieties.

Time of seeding

It is not advisable to sow seed too early. Plants that are in good condition to set at field-planting time are better than those that are too old, and have had to be hardened off to the point where they will not resume growth quickly when set into the field.

Some approximate dates for sowing

TABLE 1. APPROXIMATE DATES FOR SOWING VEGETABLE SEEDS UNDER GLASS, AND RANGES OF DAY TEMPERATURES

Vegetable	Long Island and southeastern New York	Southern-tier counties	Remainder of New York other than mountain regions	Approximate temperatures (day)
Beets	February 15-28	March 15–31	March 1–15	60–65
Broccoli	February 10–20	March 1–15	February 20–28	60–65
Cabbage, early	February 10–20	March 1–15	February 20–28	60–65
Cauliflower	February 10–20	March 1–15	February 20–28	60–65
Celery	February 10–20	March 1–15	February 20–28	60–65
Eggplant*	March 10–20	March 25–April 5	March 15–25	70–75
Endive	February 10–20	March 10–20	February 20–28	60–65
Kohlrabi	February 10–20	March 1–15	February 20–28	60–65
Leeks	February 10–20	March 1–15	February 20–28	60–65
Lettuce	February 10–20	March 1–15	February 20–28	60–65
Melons†	April 10–15	April 25–May 5	April 15–25	70–75
Onions, Sweet Spanish	January 20–31	February 10–20	February 1–10	60–65
Peppers*	March 10–20	March 25–April 5	March 15–25	70–75
Squash	April 10–15	April 25–May 5	April 15–25	65–70
Tomatoes*	March 10–20	March 25–April 5	March 15–25	65–70

*If to be transplanted twice or if transplanted once but grown in bands or pots, the seeds should be started two weeks earlier.

†Dates are for plants grown in pots or bands. In southern-tier counties plantings should be restricted to warmer soils.

vegetable seeds under glass are given in table 1. In sections with light warm soils it may pay to sow some seed at slightly earlier dates in order to grow plants that are large enough to set in the field before the usual safe date; in other words, to run the risk of losing the plants because of freezing in an attempt to obtain early maturity.

The way that the plants are to be grown influences the time that seed should be sown, particularly as to whether or not they are to be transplanted prior to setting them in the field. If tomatoes are to be transplanted about 2 inches apart in flats or transplanting beds, they should be sown about 8 weeks before date of setting in the field. If, however, they are to be transplanted into pots or bands or spaced 3 by 3 inches or 4 by 4 inches in flats or transplanting beds, they might be started about 10 weeks in advance of planting out-of-doors. If they are to be left in the transplanting bed, but thinned to give them a chance to develop, sowing seed 8 weeks in advance of planting in the open is satisfactory.

In most sections of New York State it is not safe to set tomatoes into the field before the latter part of May.

Peppers and eggplants should be grown in much the same way as suggested for tomatoes, but preferably at slightly higher temperatures.

Early cabbage seed should be sown from 6 to 8 weeks in advance of the time of planting in the field—the exact time to be determined by the distance between the plants. Well-hardened cabbage plants can be set in most sections of New York State during the middle of April.

Sowing the seed

For the production of vegetable plants, seed is usually sown in small boxes or flats. It is important to firm the soil well, especially in the corners

and along the sides of the flat, in order to prevent excessive settling after the flat has been watered. Seeding at the rate of about 10 seeds to the inch in rows 2 inches apart is common practice. Seeds of vegetable plants most commonly grown in the plant house should be sown from ¼ to ½ inch deep. Flats made with ¾-inch lumber for the ends and ⅝-inch lumber for the sides and bottom are in common use. Sizes vary. Flats 12 by 24 by 2¾ inches are extensively used by large plant growers. Cypress is a desirable lumber for flats that are to be used for a number of years. Growers who sell plants in flats often use old-crate lumber or second-hand lumber.

Spotting or transplanting seedlings

Most seedlings should be removed from the seed flats and transplanted into other flats when the first true leaves (third leaves) have formed. Plants allowed to get too large in the seed flats are certain to be spindling. The soil into which the seedlings are to be spotted should contain enough moisture so that a ball made from the soil will retain its shape but will crumble when tapped lightly. The soil is placed in the flat and packed fairly firmly, especially along the sides and in the corners of the flat. It is then leveled off and openings for the plants are made, preferably with a form that makes the holes at regular intervals. If the soil has a desirable moisture content and is properly firmed, no difficulty should be encountered from soil crumbling into the openings thus made. If part of the soil from the flat remains on the spotting board when it is lifted from the flat, it is usually due to packing the soil too firmly in the flat. Spotting boards and a flat filled with soil in which openings for plants have been made are illustrated in figure 3. Plants should be carefully removed from the seed flat to prevent breakage of roots. They are then placed in the holes in soil at a depth of from ½ to 1 inch deeper than they grew in the seed flat. The soil is then firmed about the roots of each plant by pressing downward on the soil at one side of the opening with a small dibble. It is important to do this operation in such a way that the soil is firmly in contact with the roots of the plant and the opening into which the plant was placed is entirely filled. The flat should be watered immediately after the plants are transplanted and placed in a cool place until the plants have recovered from the shock of transplanting.

The number of plants grown in a flat varies with the type of plant grown and with the market demand. In general, it is advisable to allow at least 1½ inches between plants, such as cabbage and cauliflower which are seldom grown in pots. When tomato plants are grown in flats, they should be spaced at least 3 inches apart. Those for the canning-factory crop may be as close as 2 by 2 inches. Many growers crowd too many plants into a flat. This conserves space but results in spindling growth of plants.

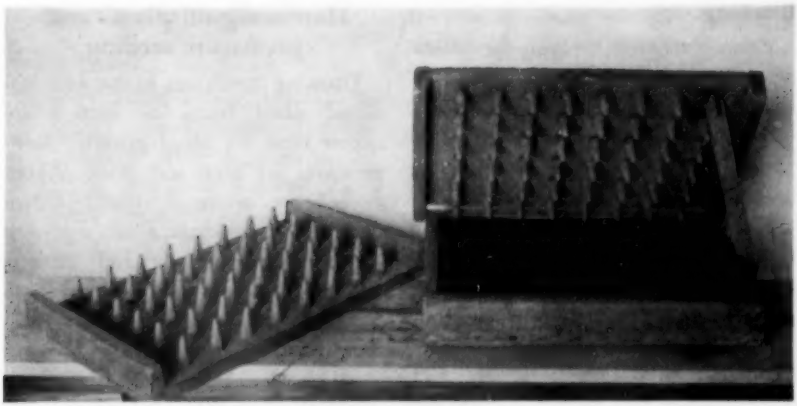

Figure 3. A spotting board assures uniform spacing of seedlings

Growing plants in pots, bands, and transplanting beds

Plants may be removed from pots with a minimum of root injury. As a result, such plants are checked little when set into the field and so mature a crop earlier than plants that are removed from flats or transplanting beds. Plants of tomatoes for early market are often grown in pots. It is a common practice to grow the plants in flats before transplanting them into the pots. In this case the seedlings may be spaced 2 inches apart in the flats.

Pots made of clay, pulp, paper, manure, and peat are on the market. Clay pots may be used for a number of years if handled carefully to prevent cracking. Plants usually are not removed from manure, peat, and paper pots that have not been treated with water-proofing materials; the pots and enclosed soil are set into the field. Treated paper pots should be removed because roots cannot grow through the paper.

A band is a container without a bottom enclosing the soil in which plants are grown. Usually, it consists of a strip of paper or wood veneer which is folded and set on a bench or bed. Because plants may be removed from bands with relatively little destruction of roots, such containers have many of the advantages of pots. Paper bands should be rigid enough to remain upright when set in place prior to being filled with soil. Paper pots and bands may be difficult to handle at setting time because of their tendency to rot.

Organisms decomposing cellulose (paper, peat, and the like) require considerable nitrogen and plants may be stunted unless additional nitrogen is applied.

Blocking

Cutting the soil between the plants with a knife or blocking hoe about a week or 10 days before transplanting increases the number of small roots within the block of soil. This tends to bind the soil together and protects the roots when the plant is finally moved from the flat or transplanting bed to the field.

Value and effects of transplanting

Transplanting saves hotbed and greenhouse space. There is little evidence that it has additional merit. One transplanting for most vegetable plants, with the exception of those grown in pots or bands, usually is all that is profitable.

Temperature and ventilation

Plants of cool-season vegetable crops, such as beets, cabbage, cauliflower, celery, and lettuce, make good growth at day temperatures of from 60° to 65° F.; those of the warm-season crops, eggplant, muskmelon, pepper, squash, and tomato, grow better at temperatures ranging from 65° to 75° F., as indicated in table 1. Night temperatures that average from 5° to 10° F. lower than the day temperatures are satisfactory.

Air in the plant-growing structure should not become so moist as to cause water to condense on the glass. Regulating the intake of fresh air is a good way to control humidity. For ventilation only, the ventilator or sash on the side opposite the wind is opened to prevent drafts that might chill the plants.

Hardening off plants and premature seeding

Growing conditions in the well-regulated plant house or hotbed are almost ideal for rapid growth. Temperatures are high and moisture conditions are optimum. Plants grown under these conditions are not well suited to withstand relatively adverse out-of-door conditions. Before such plants are transplanted to the field they should be "hardened-off."

To harden the plants, growth is checked by keeping soil on the dry side and by lowering the temperature. A deficiency of nitrogen also tends to harden plants. Hardening will not make good plants out of poor ones. The aim should be to check well-grown plants enough to withstand outside temperatures and moisture conditions.

Low temperatures, especially those ranging from 40° to 50° F., for two weeks or longer may result in considerable premature seeding in the field of beets, cabbage, cauliflower, celery, and kohlrabi plants started in the greenhouse, hotbed, or outdoor plant bed.

Watering

The soil should be soaked so that it will not be necessary to water frequently. Excessive watering leaches nutrients from the soil. By careful watering, it is possible to regulate to a large extent the type of growth made by plants. It is advisable to water in the morning so that the foliage of the plants will be dry before the humid conditions of evening.

Care in the field

Setting plants

Because transplanting reduces the root system and consequently makes for inadequate water supplies in the plant, it is advisable to water plants well a few hours before moving them to the field. Moreover, wet soil clings to the roots of the plants better than does dry soil, and as a result fewer roots are destroyed in transplanting.

Plants set early in the season out of pots or flats are usually transplanted by hand so that they may be placed in the field with a minimum disturbance of the soil around the roots. To aid in removing plants from flats, a large knife is used to cut the soil between each row of plants so as to leave each plant in its individual block of soil.

Transplanting machines are often used for setting plantings that mature later in the season. Plants with much soil adhering to their roots cannot be conveniently handled with such machines. Because early maturity is not important when producing crops for sale late in the summer, the additional check in growth caused by the greater destruction of roots is not so serious as it is for early-market crops.

Unless the soil is in good moist condition, it is well to water the transplanted plants and thus to firm the soil about the roots. Most transplanting machines apply water at the time the plant is set.

Starter solutions

Most fertilizer companies now sell relatively soluble complete fertilizers for use as starter solutions. Applied instead of water at transplanting time such solutions provide water and adequate nutrients for the plant at a time when growth is handicapped by the reduced root system due to transplanting. The starter solutions are applied in accordance with the manufacturer's recommendations.

The response that may be obtained from the use of such solutions depends on the fertility of the soil and on the crop grown. Some crops on soils well supplied with phosphates and fertilized with a complete fertilizer might not always make increased growth following the use of such solutions. Regardless of soil type, starter solutions are good insurance for rapid growth of transplants on which they can be applied conveniently.

Plant protectors

The worth of protectors varies with the season. During cool seasons they may be valuable because temperatures within the protector are somewhat higher than those outside. They also give considerable protection against frost.

During warm periods, protectors may force rapid, spindling growth of the plants. A small opening in the paper helps to reduce this hazard. It is advisable to split the caps a few days before they are removed, so the plants will become somewhat hardened before the protectors are finally removed.

It is not advisable to use hot caps if the soil is dry unless it can be irrigated because the caps keep the mois-

ture from light rains from reaching the plants or germinating seeds.

Because of the relatively dry soil conditions under the cap, a small amount of fertilizer in the soil may injure the plants. For that reason it is well to be cautious when applying fertilizer in an area where a capped plant is to be set. Unless this precaution is taken, it is advisable to apply the fertilizer broadcast.

Frost protection

Smudges of burning straw, brush, or oil have long been used to keep plants from freezing. Their effectiveness depends primarily on air conditions and the amount of heat given off by the burning material. Covering plants with baskets, burlap bags, or papers, weighted with stones or soil, has been of value when practiced on a small scale. Such covers should be removed the following morning because they exclude light.

Outdoor plant beds

In New York, plants for the production of late crops of cabbage, of cauliflower, and of celery usually are grown in outdoor seedbeds or plant beds.

Most of the cabbage and cauliflower plants so grown are produced by growers on upland soils for use on their own farms, but a large number of cabbage plants are grown by plant growers on muck soil.

In choosing a site for a seedbed on mineral soil it is important that one select well-drained, disease-free soils retentive of moisture. Clay soils are not good because the seedlings may have difficulty in breaking through the soil if it is packed by heavy rains. Careful preparation of the seedbed is essential regardless of the type of soil.

Cabbage and cauliflower seed are commonly sown in rows from 10 to 15 inches apart. Seeds of cabbage and those of similar vegetables should not be planted deeper than ½ in. Row seeding is perferred to broadcasting the seed where the soil is not so stony as to make row seeding impracticable. Plants in rows can be lifted with a spading fork with less destruction of roots than can plants in broadcast beds.

Seed should not be sown too thick or spindling plants will be produced. Twelve pounds of cabbage seed with a high germination rating is enough to seed an acre of plant bed. A pound of seed should produce enough plants to set from 3 to 4 acres of cabbage.

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